AFCRL-72-0110 LTIRF - 343/SE

DESIGN AND FABRICATION OF SOUNDING ROCKET PAYLOADS

by

Richard E. Kenyon

LOWELL TECHNOLOGICAL INSTITUTE RESEARCH FOUNDATION

450 Aiken Street

Lowell, Massachusetts 01854

Contract No. F19628-70-C-0149

Project No. 8692

Task No. 869209

Work Unit No. 86920901

SCIENTIFIC REPORT NO. 2

March, 1972

Contract Monitor: William P. Lynch

Aerospace Instrumentation Laboratory

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Prepared for

AIR FORCE CAMBRIDGE RESEARCH LABORATORIES

AIR FORCE SYSTEMS COMMAND

UNITED STATES AIR FORCE

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ABSTRACT

An ongoing effort has been maintained from February 1971 through January 1972 providing engineering design, fabrication, test and field support services concerned with various sounding rocket payloads. A concise summary of the details relative to each payload is given in the form of a one page synopsis. Other sections of this report present information describing newly implemented monitor circuit designs and a simplified method of determining the magnitude of weights for despin mechanisms. A new design of a Marmon joint clamp and results of bend tests are discussed.

SUMMARY

Six new payload assignments were received during the year. Seven payloads were carried forward from the previous year. All the new payloads were the Tomahawk class. Of the carry-overs, five were in the NIRO class, two in the Tomahawk class.

Aside from the regular support cabling and control consoles, new designs were implemented in: a despin mechanism; a squib current monitor; a multifunction monitor circuit for doors, nose cones and other mechanical motion, a control console circuit for use with the MIDAS 2000 gyro; and an improved Marmon clamp-joint design to replace screw joints at points of payload separation.

Engineering field support was provided at the: Churchill Research Range in March and December; Eglin Air Proving Ground in May; Wallops Island in August-September; and White Sands Missile Range in September. Of nine payloads launched, support functions were successfully executed completely on seven payloads and were partially successful on two others.

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1.0 INTRODUCTION

Engineering design and technical support effort has been expended during the last year to accomplish design, fabrication, test and launch tasks associated with thirteen sounding rocket payloads. Synopses of these payloads are presented in this report.

New designs have been created, tested and used on several payloads. A squib firing current monitor is described which emits a uniform pulse if the design threshold is exceeded by a rapidly rising current pulse. An improved circuit technique using constant current diodes has been applied in the design of a multifunction monitor. The circuit provides a discrete analog signal for any combination of up to four events such as door ejections. These designs are described.

A new despin unit was designed and built and flew successfuly on A08.102-2. A simplified method of determining the magnitude of the despin weights was developed and is presented in this report.

Work was accomplished on the design and test of a new Marmon clamp joint to replace earlier versions. The results are discussed.

2.0 PAYLOAD SYNOPSES

The following pages contain a brief synopsis of each payload on which work was initiated or continued during the past year.

SOUNDING ROCKET PAYLOAD SYNOPSIS

Payload : A07.913-5

Contract Monitor : William P. Lynch, CRL/LCR

Experimenter : Lawrence H. Weeks, CRL/LKB;
A. C. Faire, CRL/LKB

Rocket Type : 7.75-Inch NIRO

Experimental Objective : Measurement of radiation profiles at 2500 Å and 1450 Å. Measurement of upper atmospheric density by a falling sphere technique.

Primary Instrumentation : Four 2500 Å photometers. Four 1450 Å photometers. One 7-inch sphere with triaxial accelerometer and integral telemetry system (AFCRL supplied).

Support Instrumentation : Datametrics Type 949A1 commutator; 2 Raymond Engineering timers; RAM-5B magnetometer; Humphrey accelerometer; Monitor circuits for door ejections; Dual 6 Volt battery pack; 12 Volt battery pack; control relays; launch control console (used also with A07.913-3); test and range cables; solar aspect sensor (AFCRL); telemetry package (AFCRL).

Support Functions Provided : Four squib actuated door ejections.

Date Started : October 1968

Date Launched : May 15, 1971

Launch Site : Eglin APG, Florida

Remarks : Payload performed successfully.

SOUNDING ROCKET PAYLOAD SYNOPSIS

Payload : A07.913-6A

Contract Monitor : William P. Lynch, CRL/LCR

Experimenter : Lawrence H. Weeks, CRL/LKB;
A. C. Faire, CRL/LKB

Rocket Type : 7.75-Inch NIRO

Experimental Objective : Measurement of radiation profiles at 2500 Å and 1450 Å. Measurement of upper atmospheric density using falling sphere technique.

Primary Instrumentation : Four 2500 Å photometers. Two 1450 Å photometers. One 7-inch sphere with triaxial accelerometer and integral telemetry system (AFCRL supplied).

Support Instrumentation : Two Raymond Engineering timers; RAM-5B magnetometer; Humphrey accelerometer; Monitor circuits for door ejections; Dual 6 Volt battery pack; 12 Volt battery pack; control relays; launch control console (used also with A07.913-3); test and range cables; solar aspect sensor (AFCRL); telemetry package (AFCRL).

Support Functions Provided : Four squib actuated door ejections.

Date [illegible]d : October 1968

Date Launched : October 6, 1971

Launch Site : Wallops Island, Virginia

Remarks : Payload performed successfully.

SOUNDING ROCKET PAYLOAD SYNOPSIS

Payload : A07.017-1; A07.914-1

Contract Monitor : William P. Lynch, CRL/LCR

Experimenter : Herbert Cohen, CRL/LKB

Rocket Type : 7.75-Inch NIRO

Experimental Objective : Measurement of upper atmospheric density using the Bremsstrahlung technique; measurement of ultraviolet background radiation.

Primary Instrumentation : Two electron guns; X-ray detectors; retarding potential analyzer; photometer.

Support Instrumentation : Datametrics Type 949A commutator; three Raymond Engineering timers; RAM-5B magnetometer; Giannini -10 to +40 G accelerometer; 0 - 15 psia pressure transducer; Monitor circuits for door ejections, payload separation, squib power, power supply voltages; Dual 6V battery pack; 12 Volt battery pack; control relays; control console; test and launch cables; telemetry package (AFCRL).

Support Functions Provided : Squib actuated door ejections (2); squib actuated payload/motor separation; timed switch closures for experiment electron gun breakoff; and high voltage power.

Date Started : June 1970

Date Launched : A07.017-1 September 20, 1971
A07.914-1 September 27, 1971

Launch Site : White Sands Missile Range, New Mexico

Remarks : Payload A07.017-1 lost experiment power at lift-off. Other functions performed as designed. Payload A07.914-1 performed as designed except for loss of experimenter's high voltage after about 25 seconds of data was recorded.

SOUNDING ROCKET PAYLOAD SYNOPSIS

Payload : A08.019-1

Contract Monitor : William P. Lynch, CRL/LCR

Experimenter : Roger Vancour, CRL/PHG

Rocket Type : Nike-Tomahawk

Experimental Objective : Measurement of magnetic fields and high energy particles.

Primary Instrumentation : Two magnetometers; two particle detectors; photomultiplier (AFCRL supplied).

Support Instrumentation : Datametrics Type 949A1 commutator; two Raymond Engineering timers; RAM-5B magnetometer; Giannini accelerometer -10 to +40 G; Monitor circuits for door ejection, timer run, power supply and squib voltages; Dual 6V battery pack; 12V battery pack; control relays; control console; test and range cables; telemetry package (AFCRL).

Support Functions Provided : Squib actuated door ejection; timed switch closure for experiment high voltage.

Date Started : August 1970

Date Launched : March 19, 1971

Launch Site : Churchill Research Range

Remarks : Payload performed successfully.

SOUNDING ROCKET PAYLOAD SYNOPSIS

Payload : A07.015-4

Contract Monitor : William P. Lynch, CRL/LCR

Experimenter : A. C. Faire, CRL/LKB

Rocket Type : 7.75-Inch NIKO with 10-Inch Nose Cone

Experimental Objective : Measurement of upper atmospheric density.

Primary Instrumentation : One 10-inch sphere with triaxial accelerometer and integral telemetry system (AFCRL supplied).

Support Instrumentation : Datametrics Type 657 timer; RAM-5B magnetometer; Giannini -10 to +40 G accelerometer; Monitor circuits for nose tip eject, sphere eject, timer run, power supply voltages; 8 Volt NiCad battery; 12 Volt NiCad battery; control relays; control console; power supply console; test and range cables; telemetry package (AFCRL).

Support Functions Provided : Squib actuated nose tip ejection; squib actuated sphere ejection.

Date Started : October 1970

Date Launched : May 15, 1971

Launch Site : Eglin AFG, Florida

Remarks : Nose cone did not eject. Sphere released inside nose cone. No experimental data obtained.

SOUNDING ROCKET PAYLOAD SYNOPSIS

Payload : A08.019-2

Contract Monitor : William P. Lynch, CRL/LCR

Experimenter : Roger Vancour, CRL/PHG

Rocket Type : 7.75-Inch NIRO

Experimental Objective : Measurement of high energy particles.

Primary Instrumentation : Two particle detectors; photomultiplier (AFCRL supplied).

Support Instrumentation : Datametrics Type 949A1 commutator; two Raymond Engineering timers; RAM-5B magnetometer; Conrac -10 to +50 G accelerometer; Monitor circuits for door ejection, squib voltage; accelerometer supply voltage; Silver cell battery pack providing 6V and 12V; control relays; control console*; test and range calbes*; telemetry package (AFCRL).

Support Functions Provided : Squib actuated door ejection; timed switch closure for experiment high voltage.

Date Started : November 1970

Date Launched : March 19, 1971

Launch Site : Churchill Research Range

Remarks : Payload performed successfully.

* Supplied by Wentworth Institute.

SOUNDING ROCKET PAYLOAD SYNOPSIS

Payload : A08.102-1

Contract Monitor : William P. Lynch, CRL/LCR

Experimenter : Lawrence H. Weeks, CRL/LKB;
A. C. Faire, CRL/LKB

Rocket Type : Nike-Tomahawk

Experimental Objective : To obtain profiles at 1450 Å; 2600 Å; 2750 Å; at Lyman-α; and to detect X-ray activity. Measurement of upper atmospheric density using a falling sphere technique.

Primary Instrumentation : Pairs of photometers at: 1450 Å; 2600 Å; 2750 Å; Lyman-α. A pair of CO_2 Geiger tubes. An X-ray Geiger counter and an X-ray ion chamber. A solar aspect sensor. IR detector. A ten-inch sphere with tri-axial accelerometer and self-contained telemetry link.

Support Instrumentation : Datametrics Type 949B commutator; three Datametrics Type 657-3 timers; RAM-5B magnetometer; Conrac accelerometer -10 to +50 G; Monitor circuits for door ejections, nose cone ejection, sphere ejection, squib power, squib current, power supply voltages; four 12V NiCad batteries; control relays; control console; test and launch cables; telemetry package (AFCRL).

Support Functions Provided : Squib actuated door ejections (3); squib actuated nose ejection; squib actuated sphere ejection; timed switch closure for actuation of circuit in sphere.

Date Started : February 1971

Launch Date : Firm launch date unspecified.

Launch Site : Unspecified

Remarks : Payload is ready for scheduling integration tests.

SOUNDING ROCKET PAYLOAD SYNOPSIS

Payload : A08.103-2

Contract Monitor : William P. Lynch, CRL/LCR

Experimenter : Lawrence H. Weeks, CRL/LKB;
R. E. Good, CRL/LKB

Rocket Type : Nike-Tomahawk

Experimental Objective : Measurement of profiles at: 1450 Å; 2600 Å; Lyman-α. Al Geiger tubes and Be Geiger tube. IR profile of (O_2, $^1\Delta g$).

Primary Instrumentation : Photometer pairs at 1450 Å, 2600 Å, Lyman-α. Pair Al Geiger tubes. Be Geiger tube. Digital rotation aspect sensor. Solar aspect sensor. IR detector.

Support Instrumentation : Datametrics Type 949A1 commutator; two Datametrics Type 657-3 timers; RAM-5B-SP magnetometer; Conrac accelerometer -10 to +50 G; Monitor circuits for door ejections, squib power, timer run, battery voltages; two 8.4V NiCad batteries; two 12V NiCad batteries; control relays; control console; test and range cables; telemetry package (AFCRL).

Support Functions Provided : Squib actuated door ejections (3); timed switch closure activation of experiment high voltage supplies (2); timed switch closure providing experiment calibration pulse.

Date Started : February 1971

Date Launched : October 7, 1971

Launch Site : Wallops Island, Virginia

Remarks : Payload performed successfully.

SOUNDING ROCKET PAYLOAD SYNOPSIS

Payload : A08.102-2

Contract Monitor : William P. Lynch, CRL/LCK

Experimenter : A. C. Faire, CRL/LKB

Rocket Type : Nike-Tomahawk

Experimental Objective : Measurement of upper atmospheric density using the falling sphere technique. Flight in conjunction with satellite fly-by.

Primary Instrumentation : A ten-inch diameter sphere with a "floating ball" accelerometer and integral telemetry link.

Support Instrumentation : Two Datametrics Type 657-3 timers; RAM-5B magnetometer; Conrac accelerometer -10 to +50 G; Monitor circuits for nose ejection (1st and 2nd motion), sphere ejection (1st and 2nd motion), despin motion, squib power, squib current, timer run, battery voltage; three 12 Volt NiCad batteries; control relays; control console; test and range cables; telemetry package (AFCRL).

Support Functions Provided : Squib actuated despin, nose ejection, sphere ejection.

Date Started : April 1971

Date Launched : December 10, 1971

Launch Site : Churchill Research Range

Remarks : Despin operated correctly. Nose cone did not eject. Sphere released inside nose cone. No experimental data obtained.

SOUNDING ROCKET PAYLOAD SYNOPSIS

Payload : A08.112-1

Contract Monitor : William P. Lynch, CRL/LCR

Experimenter : Roger Vancour, CRL/PHG;
Dr. I. Michael, CRL/PHG

Rocket Type : Nike-Tomahawk

Experimental Objective : Measurement of magnetic field anomalies; high energy particle flux; UV profile. Measurement of electric field.

Primary Instrumentation : Two magnetometers, two particle detectors; photomultiplier; ESA; dual boom electric field probe.

Support Instrumentation : Two Datametrics Type 949A1 commutators; RAM-5B magnetometer; Humphrey accelerometer -10 to +50 G; three Raymond Engineering timers; Monitor circuits for door ejections, squib power, squib current, battery voltages; two 12V battery packs (silver cell); two 9V battery packs (silver cell); one 28V battery pack (silver cell); control relays; control console; test and range cables; MIDAS 2000 gyro; telemetry package (AFCRL).

Suppport Functions Provided : Squib actuated door ejections (3); timed switch closure for ESA high voltage turn-on and boom release circuit activation.

Date Started : August 1971

Launch Date : Scheduled for March/April 1972

Launch Site : Churchill Research Range

Remarks : The despin unit originally designed by LTIRF has been replaced by a self-contained unit manufactured by ThioKol.

SOUNDING ROCKET PAYLOAD SYNOPSIS

Payload : A08.113-1

Contract Monitor : William P. Lynch, CRL/LCK

Experimenter : B. M. Shuman, CRL/PHG

Rocket Type : Nike-Tomahawk

Experimental Objective : Measurement of vertical magnetic sheet phenomena at polar latitudes.

Primary Instrumentation : A Rubidium magnetometer; a triaxial flux gate magnetometer; MND-200 magnetometer; RAM-5C magnetometer; UV photometer; and an ESA.

Support Instrumentation : Datametrics Type 949 commutator; two Datametrics timers type 657-3; Humphrey H-15 accelerometer -10 to +50 G; barometric switch; Monitor circuits for door ejection, squib power, squib current, deck and skin temperature, battery voltages; MIDAS 2000 gyro; two 9V batteries (silver cell); one 12V battery (silver cell); one 28V battery (silver cell); control relays; control console; test and range cables; telemetry package (AFCRL).

Support Functions Provided : Squib actuated door ejection; timed switch closure to activate ESA high voltage; despin; pressure actuated switch closure to mark specific altitude.

Date Started : September 1971

Launch Date : March/April 1972

Launch Site : Churchill Research Range

Remarks : Despin is self-contained unit manufactured by ThioKol.

SOUNDING ROCKET PAYLOAD SYNOPSIS

Payload : A08.215-2

Contract Monitor : William P. Lynch, CRL/LCR

Experimenter : A. C. Faire, CRL/LKB

Rocket Type : Nike-Tomahawk

Experimental Objective : Measurement of upper atmospheric density using the falling sphere technique.

Primary Instrumentation : A ten-inch diameter sphere with a "balance-beam" triaxial accelerometer and integral telemetry link.

Support Instrumentation : Two Datametrics Type 657-3 timers; RAM-5B magnetometer; Giannini accelerometer -10 to +40 G; Monitor circuits for nose ejection (1st and 2nd motion), sphere ejection (1st and 2nd motion), despin motion, squib power, squib current, timer run, battery voltage; three 12 Volt NiCad batteries; control relays; control console; test and range cables; telemetry package (AFCRL).

Support Functions Provided : Squib actuated nose ejection, sphere ejection.

Date Started : October 1971

Launch Date : Unspecified

Launch Site : Unspecified

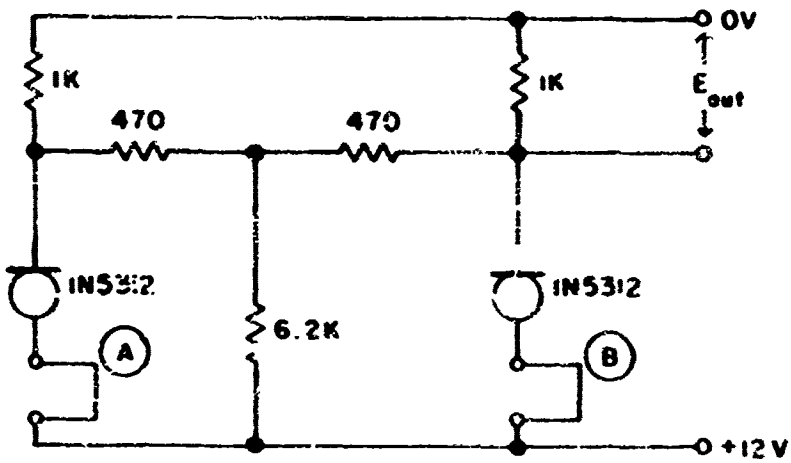
Remarks : Despin unit designed by LTIRF replaced by self-contained ThioKol despin.

3.0 MULTIFUNCTION MONITOR CIRCUIT

A monitor circuit was designed that produces discrete, identifiable voltage levels for each combination of events being monitored. For example, if four door ejections are to be monitored, the output from this monitor circuit permits determination of any combination of flight events from all four doors ejected to no ejections.

The circuit concept employs constant current diodes and a R-2R resistance ladder and is a digital to analog converter. A circuit through each constant current diode is maintained until the monitored event occurs which interrupts the circuit, usually by removal of a shorting connector.

This concept has been applied to two, three and four function monitors. The representative circuit diagrams and measured test voltages are presented in Figures 1, 2, and 3. Note the relative stability of the output signals under the influence of a supply voltage variation of plus and minus two volts.



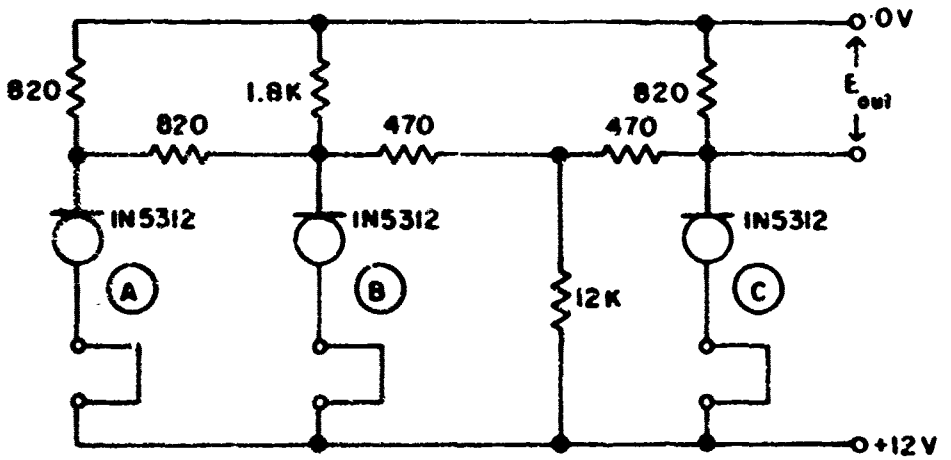
0 = Short Open

1 = Short Closed

		E_{out} for:		
A	B	E_{in} = 14.0 V	E_{in} = 12.0 V	E_{in} = 10.0 V
1	1	4.61	4.42	4.31
0	1	3.41	3.24	3.12
1	0	2.20	2.04	1.90
0	0	1.00	0.85	0.71

FIGURE 1

TWO FUNCTION MONITOR CIRCUIT

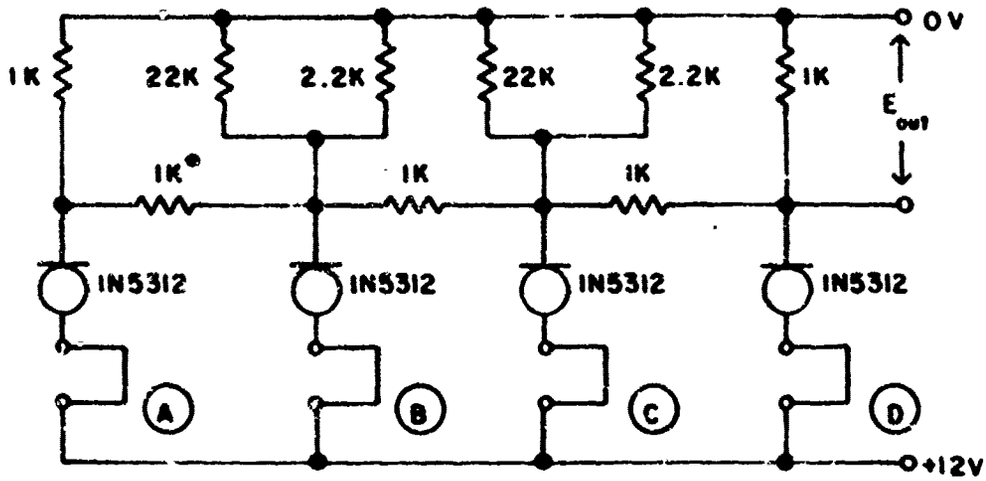


0 = Short Open 1 - Short Closed

A	B	C	E_{out} for: E_{in} = 14.0 V	E_{in} = 12.0 V	E_{in} = 10.0 V
1	1	1	4.20	4.18	4.13
0	1	1	3.68	3.63	3.60
1	0	1	3.30	3.26	3.22
0	0	1	2.77	2.73	2.69
1	1	0	1.90	1.84	1.79
0	1	0	1.37	1.31	1.26
1	0	0	0.99	0.93	0.87
0	0	0	0.46	0.40	0.33

FIGURE 2

THREE FUNCTION MONITOR CIRCUIT



0 = Short Open

1 = Short Closed

				E_{out} for:		
A	B	C	D	E_{in} = 14.0 V	E_{in} = 12.0 V	E_{in} = 10.0 V
1	1	1	1	4.86	4.87	4.83
0	1	1	1	4.53	4.56	4.54
1	0	1	1	4.14	4.16	4.14
0	0	1	1	3.81	3.83	3.82
1	1	0	1	3.60	3.61	3.60
0	1	0	1	3.26	3.29	3.27
1	0	0	1	2.88	2.89	2.88
0	0	0	1	2.55	2.57	2.56
1	1	1	0	2.31	2.31	2.29
0	1	1	0	1.97	1.99	1.98
1	0	1	0	1.58	1.59	1.59
0	0	1	0	1.25	1.26	1.26
1	1	0	0	1.05	1.04	1.05
0	1	0	0	0.71	0.72	0.72
1	0	0	0	0.32	0.32	0.32
0	0	0	0	0	0	0

FIGURE 3

FOUR FUNCTION MONITOR CIRCUIT

4.0 SQUIB CURRENT MONITOR

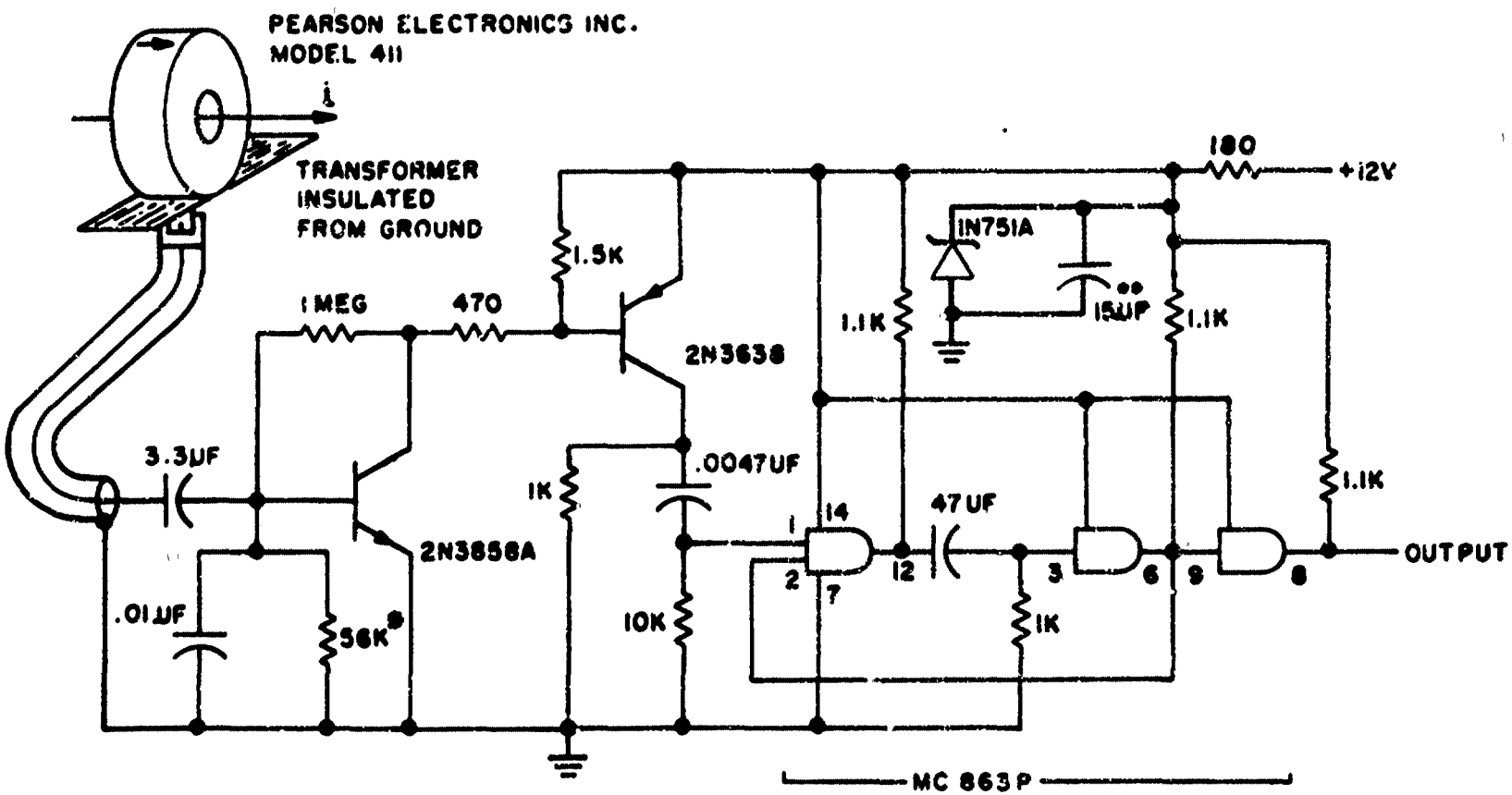
A monitor circuit was developed to detect the flow of current through the squib firing circuit when the squib fires.

A current sensing toroidal transformer was used as the basic detection device and is arranged to have the return wires to the negative battery terminal pass through its center. The transformer used is a Pearson Electronics, Inc. Model 411 which is specified to give an output of 0.1 volt per ampere current flow through the wire passed through the center of the toroid.

The monitor is completed by an amplifier and one-shot multivibrator which produces a uniformly wide, 5 volt positive pulse for application to the telemetry subcarrier oscillator.

This circuit is biased to require a minimum current of at least 3.5 amperes to flow through the transformer lead before an output pulse is produced. The current flow build-up must occur rapidly since the sensing is of the rate of change of flux field built up around the sensing lead passing through the transformer.

A circuit diagram of this monitor is given in Figure 4.



*VALUE TO BE DETERMINED AT TEST.

**TANTALUM

FIGURE 4

SQUIB CURRENT MONITOR

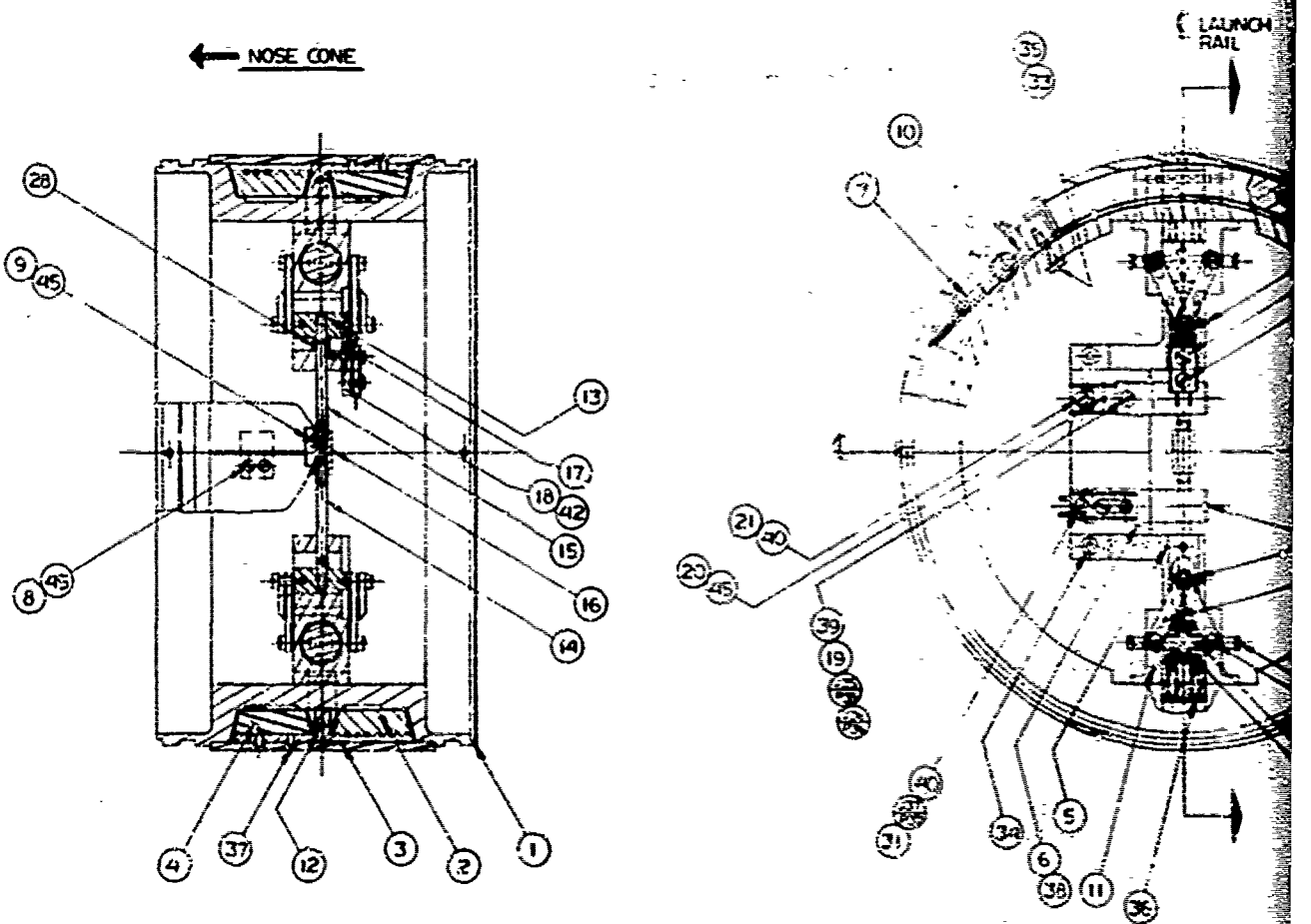
5.0 DESPIN DESIGN

A new despin device for Tomahawk payloads (9-inch diameter) was designed, built, tested and flown.

The despin was flown on payload A08.102-2 and performed as expected. An assembly drawing of the despin device is shown as Figure 5.

In the design phase of developing the despin a simplified method for determining the magnitude of the despin weights was conceived. This method is based principally on a curve which permits direct reading of a constant from which the total mass of the two weights plus one-third the mass of both cables can be easily computed.

The despin design equations are presented for two cases using the standard method of computation. The simplified method is outlined for the case of non-zero final payload angular velocity.



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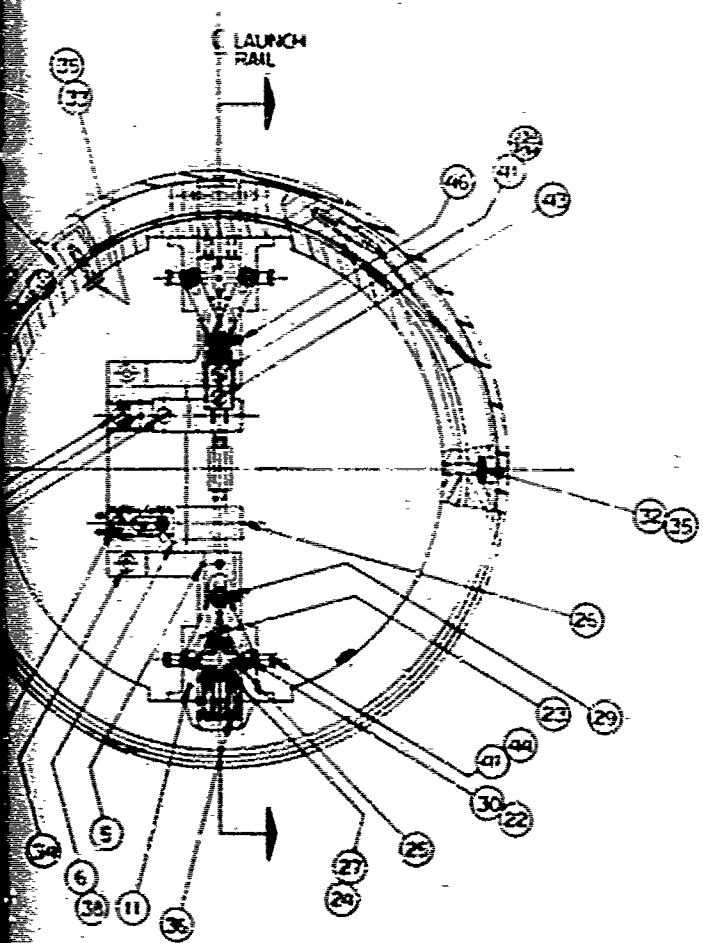
DESPIN ASSEMBLY

FIG 5

—NOTES—



BILL OF MATERIAL

ITEM	QTY	PART NO	DESCRIPTION	MFG
1	1	500240	DE-SPIN RING	LTIRF
2	2	400360	CABLE GUIDE RING	"
3	1	400356	SHROUD	"
4	2	200602	WEIGHT	"
5	16 18	200601	MOUNTING BLOCK	"
6	1	200600	TIE BLOCK	"
7	2	200595	CABLE ASSEMBLY	MISSING
8	4	MS838	GUIDE	LTIRF
9	2	101037	GUIDE	"
10	2	101036	HOOK	"
11	4	101032	LATCH RELEASE	"
12	2	101031	LATCH	"
13	2	101030	LINKAGE MOUNT	"
14	1	101029	L.H. TIE ROD	"
15	1	101028	R.H. TIE ROD	"
16	1	101027	TURNBUCKLE	"
17	1	101026	CONNECTING PLATE	"
18	1	101025	CONNECTOR BLOCK	"
19	1	101022A	MONITOR BOX	"
20	1	101021	CONNECTOR PLATE	"
21	1	100995	STRAIN RELIEF CONNECTOR	"
22	4	100914	LINKAGE (OFFSET)	"
23	4	100913	LINKAGE (FLAT)	"
24	2	100912A	SPRING RETAINER	"
25	2	100911	SHAFT (LATCH RELEASE)	"
26	2	5801	GUILLOTINE	HOLEX
27	4	½"DIA. x ½" LG. X .367 WIRE COMPRESSION		H.P.
28	1	¾" DIA. x ½" LG. X .634 WIRE COMPRESSION		"
29	4	4812	SHOULDER SCREW - #4-40	PIC
30	8	4810	SHOULDER SCREW - #4-40	"
31	1	STAR	NEED	WASHBURN
32	2	———	#8-32 x .62 B.H.M.S.	———
33	2	———	#8-32 x .50 B.H.M.S.	———
34	2	———	#8-32 x .44 S.H.C.S.	———
35	16	———	#8 INT TOOTH LOCK WASHER	———
36	4	———	#6-32 x .62 82° F.H.M.S.	———
37	4	———	#6-32 x .31 82° F.H.M.S.	———
38	2	———	#6-32 x .16 SHOULDER SS	———
39	1	———	#4-40 x .75 B.H.M.S.	———
40	3	———	#4-40 x .38 B.H.M.S.	———
41	1	———	#4-40 x .19 B.H.M.S.	———
42	1	———	#4-40 x .25 82° F.H.M.S.	———
43	1	———	#4-40 x .62 B.H.M.S.	———
44	4	———	#4 INT TOOTH LOCK WASHER	———
45	13	———	#2-56 x .19 82° F.H.M.S.	———
46	2	———	#4-40 x .38 SHOULDER SS	———

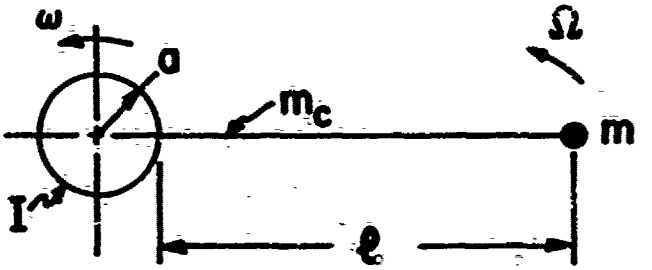
LOWELL TECHNOLOGICAL INSTITUTE RESEARCH FOUNDATION LOWELL, MASSACHUSETTS

DE-SPIN ASSEMBLY - A08102-2

SIZE B | USER'S NO. 500238

B

5.1 Yo-Yo Despin Design Equations



NOTATION:

- m = Mass of one weight (slugs)
- m_c = Mass of one cable (slugs)
- ℓ = Length of one cable (feet)
- a = Radius of payload (feet)
- I = Mass moment of inertia of payload without despin (slug-ft^2)
- ω_o = Initial angular velocity of payload (radians/sec)
- ω_1 = Final angular velocity of payload (radians/sec)
- Ω_1 = Initial angular velocity of cable and weight (radians/sec)

CASE I: FINAL ANGULAR VELOCITY OF PAYLOAD IS ZERO

ASSUMPTIONS:

A. Cable releases as it reaches the radial position.

B. No external forces or moments.

C. Cable wrapped around payload and weight at same radius, before despin maneuver.

EQUATION:

$$m = \frac{\frac{1}{2} I - \frac{1}{3} m_c \ell^2 + m_c a^2}{\ell^2 - a^2} \qquad (1)$$

CASE II: FINAL ANGULAR VELOCITY OF PAYLOAD IS NOT ZERO

ASSUMPTIONS:

A. Cable releases as it reaches radial position.

B. $\omega_1 < \Omega_1$ and $\ell^2 >> a^2$ or $\omega_1 << \Omega_1$ and $\ell^2 > a^2$.

C. No external forces or moments.

D. Cable wrapped around payload and weight at same radius, before despin maneuver.

EQUATIONS:

$$\frac{\omega_1}{\omega_o} = \frac{-B - \sqrt{B^2 - 4AC}}{2A} \qquad (2)$$

$$A = \frac{1}{2} I + \left[\frac{I + 2(2m+m_c)a\ell}{2(m+1/3m_c)\ell}\right]\left[\frac{I + 2(2m+m_c)a\ell}{2\ell} - (2m+m_c a)\right] \qquad (3)$$

$$B = -\left[\frac{2(m+m_c)a^2 + I}{2(m+1/3m_c)\ell}\right]\left[\frac{I + 2(2m+m_c)a\ell}{\ell} - (2m+m_c)a\right] \qquad (4)$$

$$C = -\frac{1}{2}\left[2(m+m_c)a^2 + I\right]\left\{1 - \frac{[2(m+m_c)a^2 + I]}{2(m+1/3m_c)\ell^2}\right\} \qquad (5)$$

CASE II (SIMPLIFIED METHOD): FINAL ANGULAR VELOCITY OF PAYLOAD IS NOT ZERO

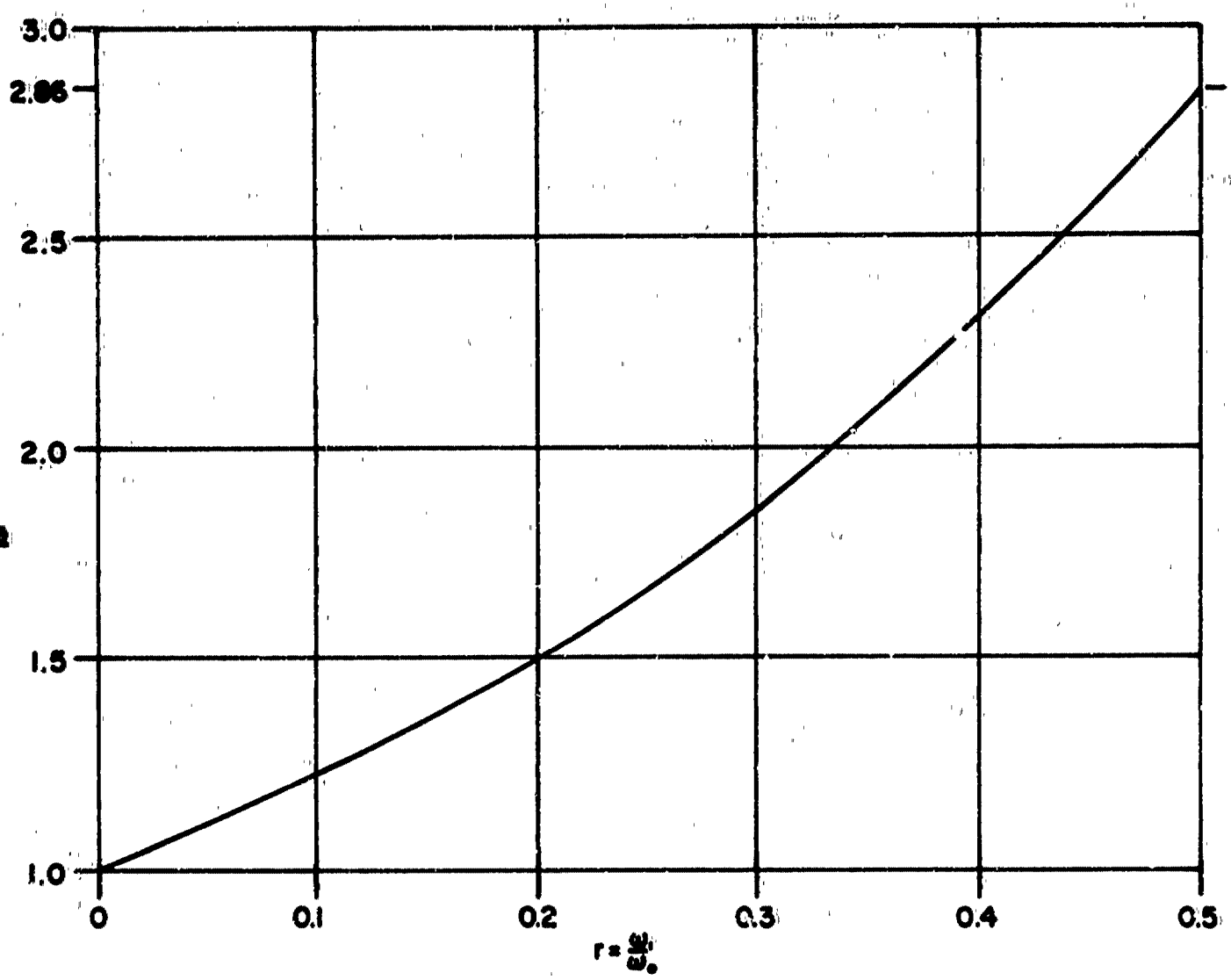
NOTATION:

m_t = Total mass of both weights + 1/3 mass of both cables (slugs)

Γ = Final angular velocity divided by initial angular velocity $(\frac{\omega_1}{\omega_o})$.

PROCEDURE:

Enter the curve of Figure 6 with a Γ value, find $\frac{I}{m_t(\ell+a)^2} = D$. Using this value of D solve for $m_t = \frac{I}{D(\ell+a)^2}$.



YO-YO DESIGN CURVE

FIGURE 6

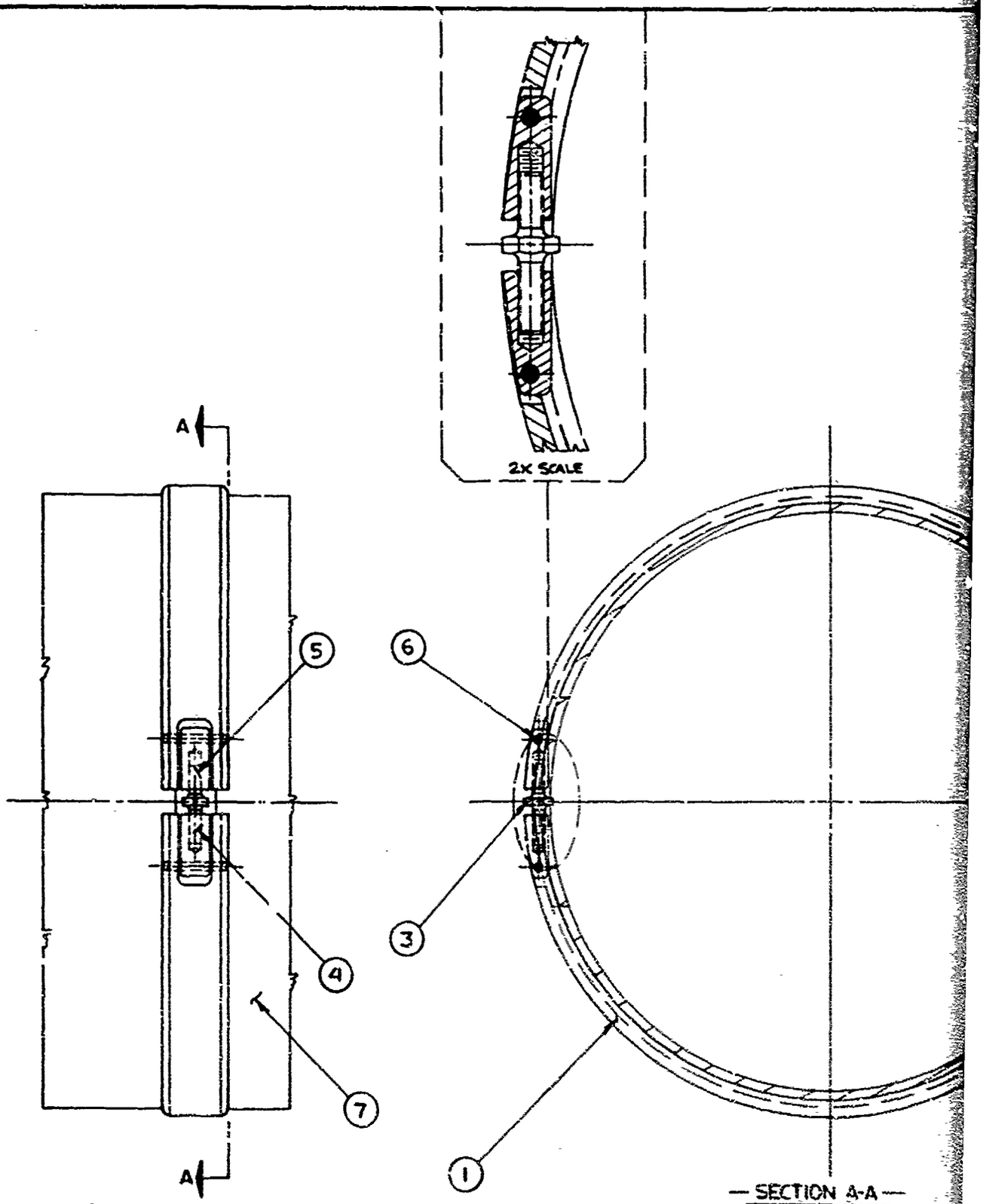
6.0 PRELIMINARY DESIGN OF A 9" MARMON JOINT CLAMP

A redesigned, prototype 9" joint clamp (LTI Dwg. 400335A), incorporating a lower profile, was developed for testing. This clamp was made of 7075-T6 aluminum alloy with each band-half retained by two pairs of 303 SS clamps which in turn are joined by a single #10-32 alloy steel socket head cap screw.

Bending tests of this joint clamp design were conducted at AFCRL utilizing two 9" dia. aluminum test skins of the same configuration as employed on the current Tomahawk payloads. It was planned to test the prototype joint clamps to failure with the objective of achieving a minimum bending moment of 100,000 in-lb before failure. The first bending test resulted in early failure of the joint at approximately a 40,000 in-lb bending moment. New clamp halves of the same design but with improved fit were made and the test repeated. The second test also resulted in failure of the joint but, due to a faulty tensile force gauge, the tensile applied force at failure could not be determined.

The third test was conducted with the remaining undamaged parts from the previous tests. This time the clamp failed with an applied force of 1,000 lbs or the equivalent of 44,000 in-lb bending moment, well below the test objective. All clamps appear to have failed in simple tension at points of stress concentrations.

An improved clamp having increased wall thickness and a newly designed holding arrangement is shown in figure 7 (ref. LTI Dwg. 400364A). This clamp has not yet been tested.



9" JOINT CLAMP ASSEMBLY

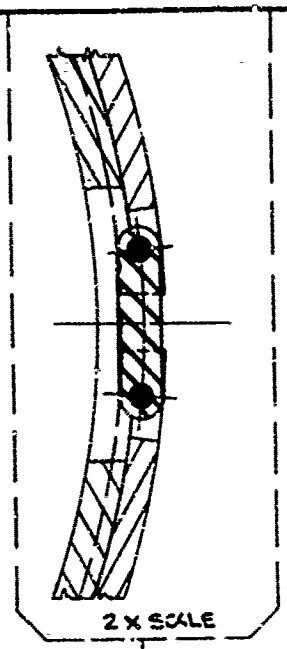
FIG. 7

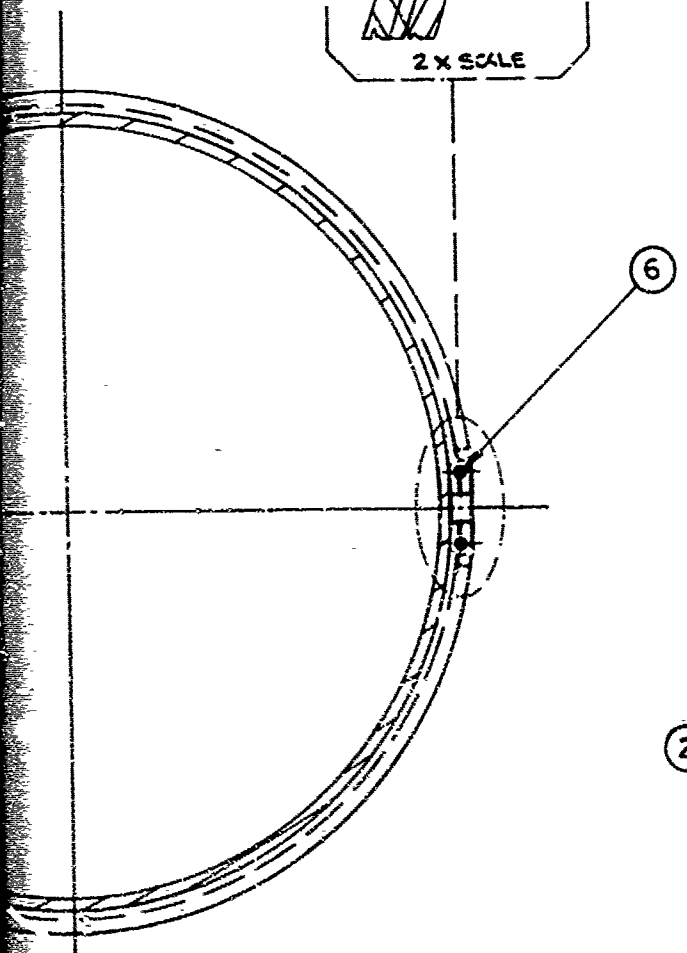
—NOTES—

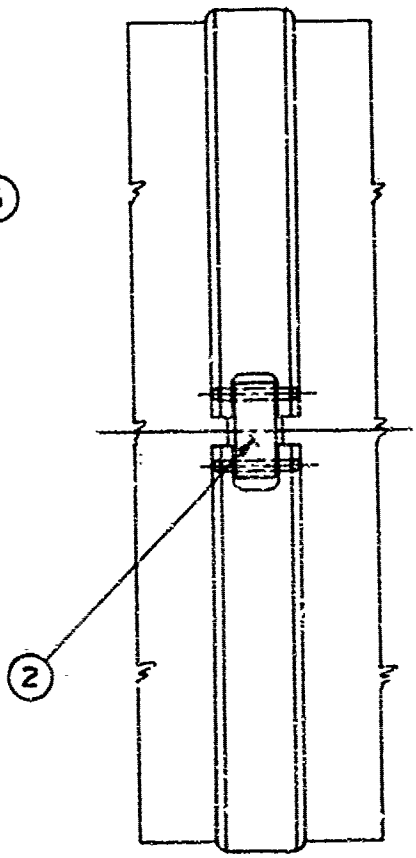
1. SEE DWG. NO. 400365 FOR DETAILS OF PARTS

BILL OF MATERIAL

ITEM	QTY.	PART NO.	DESCRIPTION	MFG.
1	1	400365-1	JOINT RING	LTIRF
2	1	400365-2	LINK	"
3	1	400365-3	TURNBUCKLE	"
4	1	400365-4	R.H. CLAMP	"
5	1	400365-5	L.H. CLAMP	"
6	4	———	1/8" DIA. X 1.00" LG. DOWEL PIN (ALLOY STEEL)	
7	1	400366	TEST PIECE SKIN	LTIRF







ETION A-A —

A	9-1-72	RE-DESIGNED CLAMP	J.P.K.
BY	DATE	DESCRIPTION	BY

LOWELL TECHNOLOGICAL INSTITUTE
RESEARCH FOUNDATION
LOWELL MASSACHUSETTS

DRAWN Pilla 2-4-72 — CHECKED J.P.K.

9" JOINT CLAMP ASSEMBLY

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13. ABSTRACT

An ongoing effort has been maintained from February 1971 through January 1972 providing engineering design, fabrication, test and field support services concerned with various sounding rocket payloads. A concise summary of the details relative to each payload is given in the form of a one page synopsis. Other sections of this report present information describing newly implemented monitor circuit designs and a simplified method of determining the magnitude of weights for despin mechanisms. A new design of a Marmon joint clamp and results of bend tests are discussed.

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